H-I TRANSLATION SERVICE LTD.
Cleveland Akron Milwaukee

January 22, 2002

To Whom It May Concern:

This is to certify that the attached document, embossed by H-I Translation Service Ltd., has been translated by a German translator who is fluent in both German and English. It is a true and accurate translation of the document presented to us, namely the:

PATENT APPLICATION
DISTRIBUTOR ELEMENT
PUBLICATION NUMBER WO 95/11744
INTERNATIONAL FILE NUMBER PCT/CH94/00206.

Peter J. Inglin
Peter J. Inglin
H-I Translation Service, Ltd.

State of Ohio
County of Cuyahoga

Before me, a Notary Public, personally appeared the above named _Peter J. Inglin_who acknowledges that he did sign the foregoing instrument and that the same is his free act and deed. In the Testimony Whereof, I have hereunto affixed my name and official seal on this_22nd_ day of_January_, 2002.

Nancy S. Carbone

NANCY S. CARBONE
Notary Public, State of Ohio
My Commission Expires May 21, 2005

31500 Shaker Boulevard
Pepper Pike, Ohio 44124
216-514-0210 Fax: 216-514-0211

hitrans@cs.com
Akron - 330-865-9106

17800 Chillicothe Road
Chagrin Falls, Ohio 44023
216-543-7619 Fax: 216-514-0211

World Organization for Intellectual Property
International Office

PCT

International Application Published in Accordance with Treaty on International Cooperation in the Area of Patents (PCT)

(51) Int. Patent Classification^6: B01J 4/04, B65G 7/06,47/91 // B01F 3/00, C02F 3/20 **A1**

(11) International Publication No.: **WO 95/11744**

(43) International Publication Date: May 4, 1995

(21) Int. File No.: PCT/CH94/00206

(22) Int. Application Date: October 18, 1994

(30) Priority Data:
3229/93-9 October 27, 1994 CH

(71) Applicant (*for all designated nations except the US*): UNIPOR AG [CH/CH]; Hegifeldstrasse, Postfach 30, CH-8404 Winterthur (CH).

(72) Inventor; and

(75) Inventor/Applicant (*for the US only*): HIRZEL, Theodor [CH/CH]; Hasenberg 70, CH-8967 Widen (CH).

(74) Attorney: Frei Patentanwaltsbüro; Hedwigsteig 6, Postfach 768, CH-8029 Zurich (CH).

(81) Designated Nations: JP, US, European Patent (AT, BE, CH, DE, DK, ES, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).

Published:

-- *with International Search Report*

(54) Title: DISTRIBUTOR ELEMENT

(57) Abstract:

To distribute fluids as finely as possible and with low pressure loss by means of a distributor element with a distributing body, the distributing body is made of a material (56) provided with pores connected to a channel system. The channel system is formed by the outer delimiting surfaces of clusters, which consist in turn of particles, and connects the inlet surface with the outlet surface of the distributing body. Distributing surfaces (2) that distribute the fluid in the distributing body before the fluid enters and flows through the distributing body are arranged in the distributing body.

FOR INFORMATION ONLY

Codes for identifying contracting PCT nations on the headings of the documents in which international applications according to the PCT are made public.

AT	Austria	GA	Gabon	MR	Mauritania
AU	Australia	BG	Great Britain	MW	Malawi
BB	Barbados	GE	Georgia	NE	Nigeria
BE	Belgium	GN	Guinea	NL	Netherlands
BF	Burkina Faso	GR	Greece	NO	Norway
BG	Bulgaria	HU	Hungary	NZ	New Zealand
BJ	Benin	IR	Ireland	PL	Poland
BR	Brazil	IT	Italy	PT	Portugal
BY	Belarus	JP	Japan	RO	Romania
CA	Canada	KE	Kenya	RU	Russia
CF	Central African Republic	KG	Kyrgyzstan	SU	Sudan
CG	Congo	KP	Korea	SE	Sweden
CH	Switzerland	KZ	Kazakhstan	SI	Slovenia
CI	Ivory Coast	LI	Lichtenstein	SK	Slovakia
CM	Cameroon	LK	Sri Lanka	SN	Senegal
CN	China	LU	Luxembourg	TD	Chad
CS	Czechoslovakia	LV	(illegible)	TG	Togo
CZ	Czech Republic	MC	Monaco	TJ	Tajikistan
DK	Denmark	MD	Maldives	TR	Trinidad
KS	Spain	MG	Madagascar	UA	Ukraine
FI	Finland	ML	Malta	US	United States
FR	France	MN	Mongolia	UZ	Uzbekistan
				VN	Vietnam

DISTRIBUTOR ELEMENT

The invention pertains to a distributor element for distributing fluids according to the introductory clause of Claim 1.

The distribution of fluids is playing a role of ever-increasing importance in modern engineering and is contributing ever more frequently to the solution of outstanding problems. The distribution of fluids is important when, for example, the goal is to bring about mass exchange between a gas and a liquid or to perform a chemical reaction. The distribution of fluids also plays a role when the goal is to conduct a gas or a liquid from a pipeline to a place where work is to be performed or where, in very general terms, an effect is to be achieved.

The known gas injection elements are examples of these types of distributor elements, where distribution processes of this kind take place. They consist, for example, of 2-dimensional distributor elements, one side of which is supplied with gas, whereas the other side is wetted by a liquid. Membranes through which extremely small slits extend and porous materials with channels and voids, through which the gas is forced, so that it emerges on the wetted side against the pressure of the liquid, are known examples of distributor elements. Known porous materials include, for example, ceramic materials, sintered materials, bodies of quartz sand bonded with epoxy resin, and similar materials consisting of granular material. In these materials, the individual grains are either welded together as in the case of sintered metal or joined together by an adhesive. If the material is not too severely compacted, it can have systems of continuous voids, which open out to the surfaces and thus form channels for the gas. In the case of the ceramic materials, we have a structure made of a compact material which has both pores and voids. Such ceramic materials are designed in the form of plates or cylinders.

A disadvantage of these known gas injection elements is that the channels extending through the material often do not have very fine cross sections, which means that the gas, upon emerging from the wetted surface, forms relatively large bubbles, which then rise relatively quickly up through the liquid. The mass exchange is thus relatively good at the surface of the gas injection element, but it tends to be rather poor in the zones a certain distance away from the element.

The standard air cushion element can be considered another example of a distributor element of this type. In the typical case, such an element has one or more nozzles or other actuating means and outlet means for the air. These means are arranged adjacent to one another and are directed toward a space, which is closed on all sides. One side of this space is formed by the surface, such as a floor, against which the air cushion element is to be supported. The other sides of this space are usually defined by an enclosure element made of rubber.

A disadvantage of these types of air cushion elements is that their nozzles or other actuating means must be followed by a space in which the air can distribute itself sideways or parallel to the floor, so that a continuous air cushion element of a certain width can be created. This means that such conventional air cushion elements are quite tall, and they are often constructed out of a relatively large number of components such as nozzles, which much also be fabricated individually. The enclosure elements, however, are relatively expensive and vulnerable to damage and are also subject to aging processes.

It is now the task of the invention to create a distributor element and a process for the production of a distributor element which does not suffer from the disadvantages indicated above, which has an especially simple design, which is easy to produce, and which results in a better, finer distribution of the fluid.

This is accomplished according to the invention in that the distributor element is fabricated out of a material which has a system of channels, which distribute the fluid in a much finer way. This is achieved in that the material consists not of individual particles but rather of clusters or agglomerates, which form the walls of the channels of the channel system. Because the clusters consist of granular material, bonded to each other by a binder, it is possible to control the formation (quantity and arrangement) of the clusters during the production of the material itself and thus also to exert an effect on the channels to thus ensure that optimum conditions are created for the distribution of the fluid.

If the distributor element is to be used to inject a gas into a liquid, the structure of the element also means that the individual bubbles which grow out of its pores can be kept very small. They then rise very slowly and thus promote the mass exchange even at some distance from the pores out of which they have emerged. Thus the entire volume of liquid can be treated with the gas, and oxygen, for example, can be injected into wastewater at a very high rate per energy unit expended. According to the invention, it is possible to design gas injection elements of this type in the form of plates and to use both the upper and the lower surfaces for gas injection.

The work of the distributor element is performed in an especially effective manner when the routes between the surface at which the gas enters and the surface at which the gas emerges are not unnecessarily long. This can be achieved by providing a suitable arrangement of gas distribution channels in the distributor element. By decreasing the length the distribution routes, it is also possible to reduce the pressure drop in the distributor element.

It is advantageous for these distribution channels to be formed by elements which act as parts of the casting mold during the casting process by which the distributor elements are produced. These elements can act, for example, as casting cores in the known manner. Thus there is no need to subject the cast distributor element to any later processing work.

If the purpose of the distributor element is, for example, to produce an air cushion between the distributor element and a base surface so that loads can be lifted, for example, the fluid, i.e., air in this case, emerges from a very large number of pores or nozzles on a surface, so that a layer of fluid, which lifts the surface, is formed between the surface and the base surface.

If forces are to be exerted by the emerging fluid, the advantage of the distributor element according to the invention is that these forces start to build up as soon as the fluid emerges from the pores; and because the material in which the pores are carried forms a solid, rigid body, the fluid is also directly supported on the surface of this body, in the areas next to the individual pores. This means that the layer of fluid can be very thin, and it also means that no special measures must be taken to prevent the fluid from escaping toward the side, since the surface area is very large in comparison with the depth of the fluid layer. Thus only a very small amount of fluid can flow away toward the sides. Other advantages are to be found in the ease with which the element can be produced and maintained. Because the channels which distribute the fluid have extremely small cross sections, they also have little tendency to clog, especially when the material apt to clog them comes from the outside. As a result, these distributor elements have longer service lives. No special cleaning methods are required. In addition, distributor elements of this type can be cast directly, or they can be produced by the further processing of a semi-finished product such as precast material.

The invention is explained in greater detail below on the basis of an example, which is described with reference of the figures, where:

– Figure 1 shows a cross section through a distributor element according to the invention;

– Figure 2 shows a longitudinal cross section through the same distributor element;

– Figure 3 shows a detail of this element;

– Figures 4 and 5 show additional embodiments;

– Figures 6 and 7 show schematic structural and functional diagrams;

– Figure 8 shows a device for the production of a distributor element of this type;

– Figure 9 shows another device; and

– Figure 10 shows another device for the production of a distributor element.

Figure 1 shows a cross section of a gas injection element 1 along line A-A of Figure 2 in the form of a distributor element with a distributing body in the shape of a flat

cylinder. A spiral-shaped distributing channel 2 is provided inside it; one end 3 of this channel is open to the outside, whereas the other end 4 is sealed off. The surface of this channel forms an entry surface for the gas.

The turns 5, 6, etc., of the distributing channel 2 are fixed in position with respect to each other by a spacer 7, which is shown in broken line. This positioning is especially important with respect to the production process. Additional spacers 8, 9, and 10 are also provided. The gas injection element 1 consists otherwise of a material 56, as described in conjunction with Figures 6 and 7. It is also possible to lead the end 4 back to the end 3 to obtain a continuous distributing channel 2.

Figure 2 shows the gas injection element of Figure 1 in cross section along line B-B. Here we can see the open end 3, the turns 5, 6 of the distribution channel 2, and the spacers 7 and 10, which here are designed by way of example as sheet metal parts bent into a wavy shape. Other designs, of course, are also conceivable but are not shown here. The end 3 is firmly attached by way of a flange 11 to the actual gas injection element 1.

Figure 3 shows a section 12 of the distributing channel 2 of Figures 1 and 2, i.e., the part which does not consist of the material 56 (Figure 1) but which is surrounded by such material. These sections are therefore inserted into the distribution body. This section consists of a hose-like filter element 13 with pores 15 and of a support spiral 14. The filter element 13 consists preferably of a porous fabric, such as a fabric made of glass fibers.

Figure 4 shows another example of a distributor element 16 without distributing channels, but preferably with a distribution space 17, by which it is connected to, for example, a gas feed line 18. If the gas is to emerge only from certain surfaces such as from the top surface 19, the other surfaces are sealed off by sealing means 20. Sealing means 20 can consist, for example, of a layer of paint or lacquer or of some other coating material.

Figure 5 shows another example of a distributor element 21, consisting of an upper part 22 made of material provided with channels. In this upper part, distribution channels 23 are provided, the walls 24, 25 of which can be lined with, for example, fabric. The distributing channels 23 are connected by connecting channels 26 to a main channel 27, which is connected to a fluid feed line 28. The distributing channels 23, which are open at one end, the connecting channels 26, and the entire upper part 22 are closed off on one side by a cover 29, which, if it is not needed to help with the distribution, can also consist of any other desired material. It is advantageous for it to be detachably connected to the upper part in a manner known in and of itself and therefore not shown specifically here, so that it can be removed to allow the channels to be cleaned.

Figure 6 shows a schematic diagram of a distributor element 30 made of the material which has already been described above and which will be described in even

greater detail below. An entry surface 31 for the fluid has been provided on this element. This entry surface 31 could, for example, correspond to the cross section of a pipe set in place there, to which the fluid is supplied. Channels, which can take very complicated paths, are present in the material. These channels open out at one end at the entry surface 31, whereas they open out at the other end at the other surfaces 37, 38, 39, 40. A limited selection of these channels is designated by the reference numbers 32, 33, 34, 35, and 36. It must be kept in mind that these channels can also have sections 41 or 42, which do not agree with the general direction of the fluid flow, but which instead extend crosswise or opposite to that general direction. This direction is indicated here, for example, by the arrow 43. Thus the fluid can also be conducted back to the surface 37 at which it entered. The exit surfaces 37, 38, 39, 40 for the fluid are in this case many times larger than the entry surface 31, which is also true of the design according to Figure 1. Thus the fluid flow slows down as it proceeds toward the outlet, which also helps reduce the pressure drop.

Figure 7 shows in schematic fashion the structure of the material out of which the distributor element is made. Here we can see the individual clusters 44 and the individual grains or particles 45 of which each cluster 44 consists. A material of this type is already known from European Patent Application No. 0,486,421, in which the production of the material is also described. The individual clusters are composed of particles, which are joined to each other by a first binder, and the clusters themselves are joined to each other by a second binder. It is also possible to see channels 46, the boundaries of which are formed by the clusters 44. The outer boundary surfaces 61 of the clusters form the outer boundaries of the channels 46.

Figure 8 shows schematically a part of a device 50, in which a distributor element 51 of this type can be produced. First, a casting mold 52, which is open on one side, a distribution channel system 53, and the starting material are prepared. The inside surfaces 60 of the casting mold define the potential entry and exit surfaces of the distributor element. The starting material consists of a granulate, which is composed of particles and a first binder, which have been pretreated in such a way that they form clusters. A portion of the starting material 54, consisting of clusters, is loaded into the casting mold 52 first. Then the distribution channel system 53 is placed in the mold, so that it now rests on the previously loaded starting material 54. The material 54 can be lightly precompacted, if desired. Then the remainder of the material 54 is added and distributed sufficiently to prevent the occurrence of large cavities, especially between the turns 5, 6, etc. Then a cover or a pressure plate 55 is placed on top, and the entire assembly is simultaneously compacted and heated in a press. As this is happening, the second binder cures, and a hard material of the previously described type is obtained. After cooling, the distributor element can be lifted out of the mold. Any projections which may have formed during casting are preferably broken off. For this reason, such operations should be done only on surfaces which are not intended as entry or exit surfaces for the fluid. This applies at least to cases in which the distributor element will be used, for example, for injecting gas into a liquid. It should be pointed out that the inside surfaces of the distribution channel system 53 also define entry surfaces of the distributor element.

The distributor element for the injection of a gas into a liquid as shown in Figures 1 and 2 and produced in the manner described above operates in the following way. Through the open end 3, gas, for example, is introduced into the distributing channel 2, and this gas then enters into the material 56 over the entire surface of the distributing channel 2. Once in the material, the gas seeks a way to the surface 57 through the channels present in the material 56 as mentioned above. At the surface, it emerges through pores 58 (Figure 7). Bubbles form under the effect of the surface tension of the liquid into which the gas is entering. These bubbles then grow, stabilize, or separate and ascend after a sufficient amount of fluid has been supplied to them. A continuous mass-exchange takes place between the gas and the liquid.

Dirt in the distribution channel can be blown out periodically. For this purpose, a closable opening 59 can also be provided afterwards. Of course, the distribution channels can also be laid out according to a different pattern. The fewer the channels with dead ends, however, the easier it is to clean them.

This arrangement of the distribution channels has the advantage that the routes traveled by the gas through the material are not unnecessarily long, with the result that there is not an excessive drop in the pressure. For normal applications such as in a clarification plant, it can be assumed that the pressure drop will be about 0.1 bar. In addition, the gas injection element can either be surrounded completely, that is, on all sides, by the liquid, or arranged in a battery, that is, directly adjacent to other, similar elements. The injection element forms in all cases a self-supporting "block", which means that it has enough intrinsic rigidity that it does not need to have any other means of support. Even a relatively thin piece of the material is quite effective in distributing the gas.

Figure 9 shows another embodiment of a distributor element, the design of which is more suitable for allowing a fluid such a air to emerge from an end surface 65, so that an air cushion 67 is formed between a base 66 and the end surface 65. The air cushion then lifts the distributor element 68 from the base against the force of gravity. The distributor element 68 has essentially the same structure as that previously described, but here it is enclosed by a rigid housing 69, which is open toward the end surface 67. The distributing body 70 and the housing 69 together form the end surface 65. It is also conceivable, however, that the housing 69 could project very slightly, as can be seen at the point designated 71, to enclose the layer of air around the sides. Because the air feed 72 is located on the side in this case, a distributor element of this type can be very thin. Its height, however, is already very limited simply because of the properties of the material out of which the distributing body is made.

Additional steps in the process can be seen in Figure 10; these steps are important when, for example, a distributor element according to the invention is used as a lifting device. The lifting of an object can be accomplished by drawing the object toward, or pushing it away from, the distributor element. The housing 69 described above also serves as a casting mold. The distributing body 70 is cast as previously described.

After the hot-pressing step, both the housing 69 and the distributing body 70 can be cut off along a line 73 by a machining process known in and of itself such as a process suitable for metal to create the end surface. Then a bore 74, which leads to a distribution channel 75, can be provided to establish a connection for the fluid. Here again, spacers are provided between the individual sections of the distributing channel 75. These are not shown specifically here, however, for the sake of simplicity.

The material of which the distributing body consists can be built up in many different ways. Especially suitable are particles of metal or metal oxides, especially particles based on aluminum such as aluminum itself, aluminum alloys, and aluminum oxide. Mineral materials can also be used as particles. Binders of epoxy resin have been found to give especially good results. It is preferable for most of the particles to have a uniform size in the range of 46-160 μm.

The porosity and the process of channel formation itself can be influenced by the duration of the mixing process used to combine the particles and the binder, this being the process during which the clusters are formed. The type of mixing process used also exerts an effect. Stretching and folding the mass is an especially favorable way to mix the components.

The distributor element for fluid according to the invention can thus serve various purposes. As described above, it can be used to introduce a first fluid into a second fluid, to mix two fluids, etc. It can also be used to build up forces such as suction forces or compressive forces and thus serve as a support element, or it can be used to raise loads without the occurrence of any static friction or sliding friction between solid bodies. In the same way, therefore, it is also possible to influence the friction between a fluid and the surface against which the fluid is flowing by designing the exposed surface as a distributing body. The fluid emerging from the distributing body forms a boundary layer, which controls or reduces the resistance which the arriving fluid experiences at this exposed surface. Such distributor elements can also be used to distribute hot air or steam and thus not only to distribute the substances themselves but also primarily to distribute the associated physical variables or properties such as precisely the heat, thermal capacity, etc., of the those substances. For example, steam from a steam line can be distributed by elements of this type in such a way that the steam is distributed over a wide area. Thus large surfaces and even non-contiguous surfaces separated by edges can be heated uniformly, or uniform heat transfer can be achieved at a surface of this type. Thus additional applications within this framework which are not described specifically here but which nevertheless belong to the invention are also readily conceivable.

CLAIMS

1. Distributor element for distributing fluids, characterized by a solid distributing body (30) with an entry surface (31) and an exit surface (37, 38, 39, 40), which body consists of a material with pores (58) in its surface, this surface forming the exit surface for the fluid, which body also has a channel system (32, 33, 34, 35, 36), which is formed by the external boundary surfaces of clusters (44) of particles (45), the channels being connected to the entry surface and to the exit surface.

2. Distributor element according to Claim 1, characterized in that the exit surface (37, 38, 39, 40) is many times larger than the entry surface (31).

3. Distributor element according to Claim 1, characterized in that the entry surface (2, 17) is located inside the distributing body.

4. Distributor element according to Claim 3, characterized in that the distributing surface (2) extends along a spiral path.

5. Distributor element according to Claim 1, characterized in that the entry surface is provided with a filter element (13).

6. Distributor element according to Claim 1, characterized in that the entry surfaces and the exit surfaces are unmachined.

7. Distributor element according to Claim 1, characterized in that the distributing body is rigid and self-supporting.

8. Distributor element according to Claim 1, characterized in that it is used to introduce gases into liquids.

9. Distributor element according to Claim 1, characterized in that it is designed as a suction element for drawing and holding objects.

10. Distributor element according to Claim 1, characterized in that it is designed as a means for lifting loads.

11. Distributor element according to Claim 1, characterized in that it designed in the form of a plate, is provided with exit surfaces above and below, and is designed to inject gases into liquids.

12. Process for the production of a distributor element for a fluid, characterized in that the entry and exit surfaces (60) for the fluid, which surfaces form the boundaries of a casting space, are selected; in that clusters (44) consisting of granular material (45) and a first binder are formed outside the casting space; in that the clusters are then mixed with a second binder and loaded into the casting space; and in that the

clusters are pressed and heated in the casting space, so that a solid material with channels between the clusters is formed in the casting space.

13. Process according to Claim 12, characterized in that, first, the casting space consists only of the exit surface; in that a portion of the clusters and a portion of the second binder are loaded into the casting space; in that the entry surface is introduced into the casting space to act as a core; and in that finally the remainder of the clusters and the rest of the second binder are loaded into the casting space.

14. Process according to Claim 12, characterized in that the boundaries of the entry and exit surfaces are formed by machining the surfaces provided for this purpose.

15. Process according to Claim 11, characterized in that a casting mold for a distributing body is produced; in that the casting mold is then also used as a housing for the distributing body; and in that a common surface (65) of the housing and of the distributing body is produced by the joint machining of the distributing body and the housing along the common surface.

16. Process according to Claim 11, characterized in that a casting mold for a distributing body is produced; in that the casting mold is then also used as a housing for the distributing body; and in that a common surface of the housing and of the distributing body is produced by the machining of the distributing body along the common surface.